THE CONSULTATIVE GROUP ON BIOLOGICAL DIVERSITY

BIODIVERSITY

Winter 2010 Volume 20, Number 1

Emerging Technologies and a Sustainable, Healthy, Just World: The Case of Human Reproductive and Genetic Technologies

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Synthetic biology is the rapidly developing field devoted to engineering life from the ground up. It has recently generated headlines about startling applications such as the effort to artificially construct a living bacterium, molecule by molecule. But one of its leading practitioners doesn't think the engineering of life will stop there. Stanford University's Drew Endy recently told The New Yorker:

"What if we could liberate ourselves from the tyranny of evolution by being able to design our own offspring? Think about what happens when you really can print the genome of your offspring. You could start with your own sequence, of course, and mash it up with your partner, or as many partners as you like."

Synthetic biology is just one of a set of powerful emerging technologies challenging efforts toward environmental sustainability, human health, and social justice. The ongoing controversies surrounding genetically-modified crops are just the beginning. Biotech companies are now deploying cloned and genetically modified farm animals.

Nanotechnology, or manufacturing at the atomic scale, proposes to remake the world "from the bottom-up" and simple forms of nanotechnology are already in use in over a thousand consumer products, despite a dearth of safety studies. Soon, neural interfaces may expand and alter cognitive processes. And some human reproductive and genetic biotechnologies are already paving the way for "designer babies."

These technologies are not just "emerging" – they're also "converging." They often mutually reinforce each other and blend together at the levels of cells, genes, and molecules. And while many of the applications being developed or envisioned are likely to be beneficial, others come with significant environmental and social risks that have yet to be confronted.

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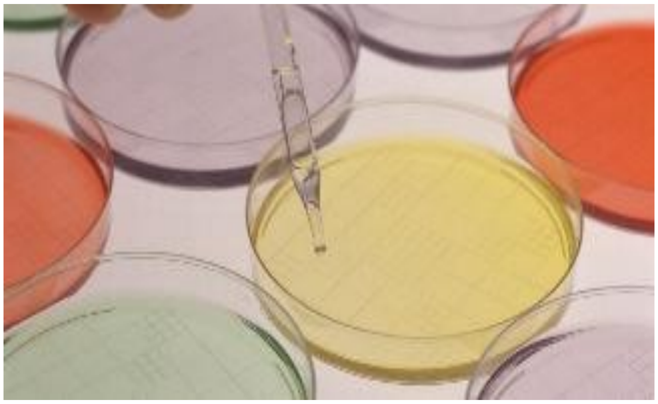


Some applications could radically transform the global economy, our natural environment, and human nature itself. Drew Endy's comment, for example, suggests how easily projects to engineer bacteria for the production of useful chemicals can slide into profoundly dangerous efforts to redesign future children and generations. In this view, living organisms and non-living matter are effectively indistinguishable, and are proper subjects for deliberate modification of any sort.

Environmentalists are in a position to play a critically important role in determining how these technologies are ultimately developed, used and regulated. Those of us concerned with protecting the natural world and its biological riches have been grappling for decades with issues involving the technical manipulation of the natural world, and can bring the lessons we have learned to bear on these emerging technologies.

One key environmental lesson, of course, is the need for precaution in the face of powerful new technologies. Another is the conviction that they are appropriate subject matter for public policy, and should be subject to democratic and accountable governance – especially when they can radically alter the natural and social world, damage human health, and exacerbate inequalities.

Human Genetic and Reproductive Technologies

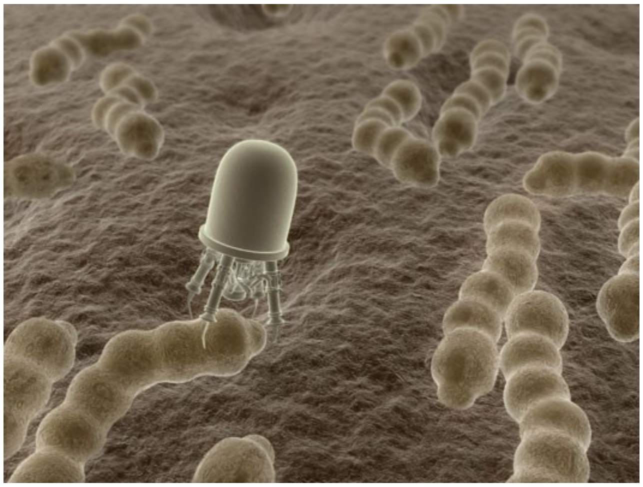
This article focuses on human reproductive and genetic technologies, though much of its analysis is applicable to nanotechnology, synthetic biology, and other domains of emerging technical innovation. Some new and emerging applications of these human biotechnologies are worthy of enthusiastic support; others hold both promise and challenge, and should be handled with care.

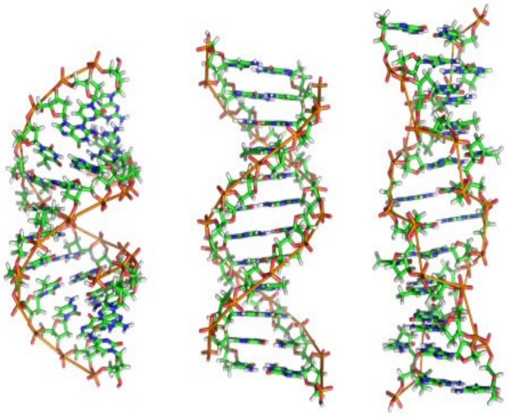
For example, a wave of direct-to-consumer genetic tests claim to offer information ranging from the frivolous (Do you have the gene for soft ear wax?) to the profound (Do you have genes for an untreatable, fatal illness?). Matters of privacy, accuracy, and appropriate counseling need to be addressed by robust policy.

Other human biotechnologies require even more careful scrutiny. Most disturbing are techniques - current and future - to influence and potentially "seize control" of human evolution. A small but disturbing number of influential figures advocate the use of genetic and reproductive technologies to engineer the traits of future children, in ways that would then be passed on to all subsequent generations.

Of course, this is not modern society's first effort at influencing the human gene pool. Programs in Nazi Germany to sterilize and ultimately to murder those deemed undesirable are well-known. Fewer people are aware that the movement for eugenics - literally Greek for "good birth" - was actually launched in the United States and led to tens of thousands of forced sterilizations, a practice endorsed by the US Supreme Court and continued into the 1960s.

Contemporary advocates of a new high-tech, market-driven eugenics based on genetic and reproductive technologies acknowledge that it would likely exacerbate social inequality. Princeton biologist Lee Silver writes in Remaking Eden: Cloning and Beyond in a Brave New World that after some generations of inheritable genetic enhancement, "the economy, the media, the entertainment industry, and the knowledge industry [will be] controlled by members of the Gen-Rich class…Naturals [will] work as low-paid service





providers or as laborers…entirely separate species with no ability to cross-breed, and with as much romantic interest in each other as a current human would have for a chimpanzee.” This is not issued as a warning; Silver believes not only that this future is inevitable, but that it should be embraced.

These kinds of applications represent a profound challenge to foundational environmental values. Some techno-enthusiasts suggest that we should renounce the natural world altogether and explicitly reject a precautionary sensibility. The environmental community has a deep interest in confronting these challenges, and can play a key role in meeting them.

If these emerging and converging technologies are to be used and regulated wisely, we must approach them with the care and sensibility that environmentalists have developed for other powerful technologies: with precaution and careful forethought about consequences; with health, human rights, and sustainability firmly in mind; and with the conviction that democratic participation in shaping these technologies and democratic oversight of their use is justified and urgently needed.

Needed Policies

The good news is that policies that encourage responsible uses and discourage misuses of human genetic and reproductive technologies are not only feasible, but have already been successfully implemented in many jurisdictions. Only a few applications - notably reproductive cloning and inheritable genetic modification - need to be removed completely from the table; this has been done in nearly 50 countries to date. Several international bodies, including the Council of Europe and UNESCO’s International Bioethics Committee have also taken strong stands against these applications.

A number of countries have adopted public policies tackling a broader range of reproductive and genetic technologies, so that they can be used appropriately and regulated responsibly. The most comprehensive models are Canada's Assisted Human Reproduction Act and the United Kingdom’s Human Fertilization and Embryology Act. Each establishes a government agency that licenses and monitors research and commercial facilities that work with human embryos. Both were preceded by extensive and robust public engagement and consultation methods, which are also used in the agencies’ continuing work.

Unfortunately, the United States has neither put policy in place nor provided vehicles for public involvement. We have no federal laws addressing reproductive cloning or inheritable genetic modification. We have no enforceable rules to prevent future “OctoMoms” or programs like the one recently advertised by a Los Angeles fertility clinic to select the hair, eye, and skin color of future children.

Thinkers, Advocates, and Organizations

In order to be effective, public policies need to be accompanied by widespread and robust understanding of the need for accountability and responsible oversight. A spectrum of voices is providing the intellectual foundation and pragmatic plans for a cautionary approach to powerful technologies.

Jurgen Habermas, one of the most influential living philosophers, takes on these matters in *The Future of Human Nature*. Political philosopher Michael Sandel addresses them in *The Case Against Perfection* and in his popular Harvard University course on justice. He notes that, "It is tempting to think that bioengineering our children and ourselves for success in a competitive society is an exercise of freedom. But changing our nature to fit the world, rather than the other way around, is actually the deepest form of disempowerment."

A number of environmentalists have also become deeply involved in the issues. Bill McKibben, whose 1989 book *The End of Nature* was the first sustained popular warning about climate change, explores the intrinsic connections between the inadvertent technological transformation of the earth's climate and the prospect of a deliberate technological manipulation of human nature in *Enough*, subtitled in the United Kingdom *Genetic Engineering and the End of Human Nature*.

Other perspectives strengthen the case for a precautionary approach to these powerful emerging technologies. Given their history as targets, people of color and people with disabilities are particularly sensitive to potentially eugenic endeavors. Feminists and women's health advocates bring another essential perspective, since women's bodies are the site of experiments in "better" reproduction. Human rights advocates recognize efforts to alter our genome as a path to division and oppression.

Other emerging technologies, especially nanotechnology and synthetic biology, raise more familiar but still urgently pressing issues of potential damage to human health and the environment. The Consortium for Science, Policy and Outcomes at Arizona Statue University is developing innovative "anticipatory governance" frameworks for powerful technologies in general.

This summer, the Center for Genetics and Society is organizing the first of an annual series of invitational meetings of individuals and organizations working to ensure responsible societal oversight of emerging and converging technologies, with a special focus on human genetic and reproductive technologies. There is widespread agreement in the public and among policy makers that efforts to dramatically intervene in the human genome should be off limits, and that other powerful reproductive and genetic technologies must be brought under effective and accountable oversight. We have a rare window of opportunity to establish understandings and policies that will allow these technologies to be used for beneficial societal purposes, while preventing their use for pernicious applications that could endanger the entire natural world, including plants, animals, humans and ecosystems.

This essay is developed from two webinars hosted by the CGBD Horizons Committee, with presentations by Marcy Darnovsky of the Center for Genetics and Society and David Guston of the Consortium for Science, Policy and Outcomes. The webinar visuals can be accessed here (http://www.geneticsandsociety.org/downloads/emerging_technologies_webinar.ppt) and here (http://www.geneticsandsociety.org/downloads/emerging_technologies_webinar_2.ppt).

For information on the coming invitational meetings addressing emerging and converging technologies, please contact Jesse Reynolds at jreynolds@geneticsandsociety.org

President's Message

The Missing Piece of the Climate Puzzle

Steve Whitney, *Bullitt Foundation*

Lost in the debate over how best to control greenhouse gas emissions from combustion of fossil fuels is the simple fact that it won't be enough. Not that it isn't important. Without a rather dramatic decrease in the production of heat-trapping carbon dioxide (C02) emissions from fossil fuels the concentration of C02 in the atmosphere will reach unprecedented levels in very short order.

Already, concentrations of C02 in the atmosphere exceed 387 parts per million (ppm), some 70 ppm higher than the year I was born, and some 40 ppm above what many climate scientists consider safe levels. By 2050, without aggressive action, we can expect to see concentrations approaching 500 ppm, unleashing what Dr. James Hansen of NASA's Goddard Institute has called " . . . a devil's cauldron of melted icecaps, bubbling permafrost, and combustible forests from which there will be no turning back."

Hyperbole aside, it turns out that even under very aggressive fossil fuel emission reduction scenarios, including the unlikely global phase out of coal by 2030, the best we can do by way of limiting C02 concentrations is something in the 400-425 ppm range -- still far too high to safely avoid catastrophic consequences. Finding a solution to this C02 reduction gap is a challenge of enormous proportions. Members of the Consultative Group on Biological Diversity can help ensure the challenge is met.

In the biosphere a significant amount of carbon is stored in living organisms, or in their dead or partially decomposed remains. Photosynthesizing organisms use atmospheric C02 as the basis for the complex chemical compounds that are essential for life. In the process C02 is utilized and stored in the body or structure of the organism.

The flip side is that these organisms also produce C02. When the amount of atmospheric carbon absorbed through photosynthesis is equal to the amount released into the atmosphere by respiration, burning, or decomposition; then the concentrations of atmospheric C02 are relatively constant and the carbon cycle is in balance. Unfortunately, the Earth's natural carbon cycle is not now in balance, not even close.

A recent report from the United Nations Environment Program estimates that there is almost three times the amount of carbon stored on the land than is now present in the atmosphere. That's the good news. The bad news is that this vast store of carbon is rapidly diminishing as humans clear land for settlements and economic activities. Approximately 15 percent of annual global C02 emissions are attributable to such land clearing. This continuing imbalance in the carbon cycle is a double whammy – it exacerbates our atmospheric greenhouse gas problem, and it affects rates of carbon capture and storage on the land, usually for the worse.

So how are we going to bring atmospheric CO2 concentrations down to safe levels? Four things need to happen.

First, existing biocarbon stores must be protected and their current high rate of loss reduced dramatically. This will require a halt in the loss of natural vegetative cover for human settlement and agriculture.

Second, historically depleted stores must be replenished through an aggressive policy of ecosystem restoration and improved management practices on all lands, especially working agricultural and forestry lands.

Third, where appropriate, opportunities to enhance carbon storage in suitable areas must be pursued, such as the planting of fast growing trees on otherwise tired and unproductive former agricultural lands.

Fourth, to make real progress we must not allow all of our biocarbon storage gains to be offset, or nullified, by new sources of CO2 pollution. That just won't get us where we need to be.

Whatever the techniques applied, the goal must be nothing short of a course reversal when it comes to biocarbon. We need to create a political and economic context in the United States within which far more C02 is stored annually in biological systems than is released from them. By addressing this missing piece of the climate puzzle, the U.S. can demonstrate global leadership by helping solve the problems of a warming world.

Steven Whitney is a Program Officer for the Seattle-based Bullitt Foundation, and President of the Consultative Group on Biological Diversity, a national association of environmental foundations.

CGBD WORKING GROUPS

Climate and Energy

The Climate and Energy Funders Group closed out 2009 by organizing a host of events for the 90 funders attending COP 15 in Copenhagen. The events ranged from morning briefings from key global advocates, networking receptions, and a high-level morning briefing featuring Al Gore and Jet Li. CGBD members were able to gain access to the negotiations (until logistics completely broke down) thanks to us being an accredited organization by the United Nations.

The morning briefing also helped global funders connect, compare strategies from across regions, and explore how to better connect the global climate and energy funding community. It was a chaotic event, to say the least. When the logistics broke down, we secured a place for funders to gather, which was critical under the circumstances.

The Funders Group is busily planning our 2010 Annual Meeting on April 27-29 in Denver. Given the dramatic shifts in the understanding of momentum or lack thereof, for climate and energy policy, we hope the meeting will enable a set of conversations around 2010 and 2011 strategies.

Marine Conservation

Throughout 2009, the Marine Conservation Working Group convened regular conference calls to address a variety of marine conservation issues. Conference call topics included: the Ocean Project's (TOP) report, "America and the Ocean, Environment, and Climate Change: New Research Insights for Aquariums, Zoos, and Museums;" trade in coral ornamentals – an update on science and U.S. policy; and technological innovations that help visualize decisions and scenarios and compile data into a useable form.

The Working Group convened its annual meeting on March 31-April 3 in Laguna Beach, California. With a theme of, "*Ensuring Marine Conservation Amidst a Sea of Chaos*," the meeting focused on opportunities for collaborative marine conservation grantmaking during current challenging economic times.

The program began with a panel of Working Group members addressing the challenges and opportunities for marine conservation with the changes in federal administration. Several sessions then focused on marine conservation funding in difficult economic times, including (1) funder responses to political opportunities; (2) funder responses to the downturn; (3) opportunities for improved funder collaboration; and (4) improving funder tools. Other topics addressed during the meeting included: linking marine conservation and community planning, with an emphasis on marine spatial planning and ocean zoning and community-supported fisheries; and the looming threat of ocean acidification.

The Working Group also conducted its annual member survey; this was the seventh year the survey has been conducted. The results of the annual survey: provide information on the strategies, issues and level of grantmaking for each of the Marine Working Group members; allow funders to compare their marine grantmaking programs with other leading marine funders; and assist Working Group members as they look for potential partners in collaborative funding.

Conservation Science

Following up on the CGBD's funder briefing on climate adaptation in 2008, a group of funders has continued to work together to look for opportunities for collaboration. Over a series of meetings and conference calls, the group identified several topics were of particular interest. The group shared the concerns of the public lands funders regarding issues of renewable energy development and transmission siting.

In addition, the group expressed an interest in entering into discussion with the leaders of the CGBD's Climate & Energy Funders over this specific issue, as well as more generally over issues of climate adaptation. Finally, the group will be tracking federal legislation closely, particularly the climate adaptation title. Monitoring the work of the Western Governors' Association on wildlife corridors was also an interest of several funders.

During the summer, a subset of CGBD funders, with the support of the Conservation Science Working Group, commissioned a report to provide funders with a better understanding on the intersection between wildlife habitat conservation and renewable energy siting and transmission. The intent of the report was to provide a roadmap for addressing this complex issue, which cuts across many of our funding programs and has very significant implications for the conservation community.

Following up on the report, in October the Working Group hosted a funder briefing on *Reconciling Wildlife Habitat Needs and Renewable Energy Development in the West*. The briefing focused on framing issues and identifying solutions, reviewing current and planned Western policy initiatives, and exploring opportunities for funder collaboration. Briefing topics included: The Habitat, Wildlife, Renewable Power and Transmission Nexus; and Case Studies: Issues and Promising Pathways. These sessions were followed by a facilitated funder-only discussion of near-term opportunities for collaboration and long-term objectives and funding strategies.

Land & Freshwater Conservation

During 2009, the Land & Freshwater Conservation Working Group convened monthly conference calls on a wide range of terrestrial and freshwater conservation issues. Call topics included: US federal Clean Water Act; working with indigenous communities on land conservation; biofuels and forest sustainability; implication of potential climate change legislation on water resources; naturally green community planning; transforming water infrastructure in the face of climate change; and the US Forest Service Roadless Area Conservation Rule.

In late February in Washington, DC, the Land & Freshwater Conservation Working Group hosted a briefing for funders concerned with the policy and management of federal lands. The meeting opened on the topic of public lands in Congress and the Administration, with sessions entitled "The View from the Hill" and "Perspectives on the New Administration."

The program then turned to key public lands policy and management issues in the next two years, with sessions addressing: the economic stimulus package and public lands; US Forest Service Roadless Areas; wilderness; Reform of the 1872 Mining Law; climate change & energy policy. The meeting closed with a session on prospects for meaningful funder collaboration on these and other public lands issues.

Gulf of California

Improving the effectiveness of marine protected areas in the region continues to be a major focus for the Gulf of California (GOC) funders. Many would like to see greater numbers and size of no-take reserves within existing marine protected areas. Enforcement, management effectiveness and capacity-building also continue to be of concern.

The CGBD is working with funders to explore solutions, including funder collaborations such as the Gulf of California Marine Endowment. CGBD staff is also working with the Packard Foundation to organize an upcoming workshop in late February on Marine Protected Area monitoring frameworks and models that will include participants from Mexican government agencies and NGOs, as well as experts from California and abroad.

Spurred by the GOC funders' collective interest in learning more about environmental issues and threats in the Mexican mainland states of Sinaloa and Nayarit, CGBD staff organized a funder trip to the area in early January 2010. Trip participants began in Mazatlan, visiting with new NGOs forming in Sinaloa, and visited various watersheds affected by large new dam projects. The group then visited fisheries reform and catch share projects in Altata, Sinaloa, and a demonstration of recently improved selective fishing gear.

An overflight of Sinaloa and Nayarit offered a bird's-eye perspective on Marismas Nacionales, one of the most important (and threatened) wetlands in North America. The final part of the trip focused on coastal development and other threats to wetlands conservation in both Sinaloa and Nayarit, and also served as an introduction to small new NGOs and community groups working on coastal development issues in Nayarit.

Gulf of California funders in Sinaloa, Mexico

Health & Environment

In 2009, the Health & Environmental Funders Network (HEFN) reached its tenth anniversary. To celebrate this occasion and the growth in the field, HEFN engaged in two special projects:

Stories Project

HEFN designed a new splash page for its website, enabling groups from the field to share stories of their successes using text, video, audio and photographs. The stories can be seen online at www.hefn.org.

Tenth Anniversary Meeting

HEFN held a national meeting in Washington, DC to celebrate its tenth year. Programming highlighted issues important to each of HEFN's working groups, including: chemical policy reform, environmental health and justice, California, and women's environmental health. Additionally, HEFN organized a "Morning on the Hill" day, providing funders the chance to meet with Congressional and Executive Branch policy makers. The meeting attracted 54 funders and received very positive feedback.

Conference Calls

In 2009, HEFN continued its funder conference call series, hosting twelve calls on issues of high interest, including: A funder call with Goldman Prize winner Maria Gunnoe; Environmental Justice and Federal Chemicals Policy Reform; Women's Voices in Chemicals Policy Reform; and Mapping the Money: Grants Tracking & Projections for the Field. In addition, HEFN supported unstructured calls for each of its working groups. This gave funders the opportunity to share information and discuss strategy on a regular basis.

Funder Collaboration

Lastly, HEFN supported funder collaboration through its four working groups: HEFN's Catalysts for a Healthy Future (focused on chemical policy); the Environmental Health and Environmental Justice; the HEFN California Working Group; and the Women's Environmental Health Working Group. For each of these working groups, HEFN:

- Provided a space for regular communications and strategic discussion among funders;
- Served as a philanthropic point of contact for efficient information-sharing between funders, advocates, policymakers, researchers, and NGOs in the field;
- Provided information resources useful for funder decision-making, engagement, and collaboration;
- Conducted outreach into philanthropy, and across HEFN working groups, to identify more areas for funder collaboration.

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